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FLUID PUMP

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[0001] Prior Art

[0002] The present invention is based on a fluid pump as generically defined by the preamble to claim 1.

[0003] A fluid pump of this kind embodied in the form of a gear pump is known from DE 196 25 564 A1. This gear pump is provided for a fuel injection apparatus of an internal combustion engine and has a housing that contains a pump chamber. The pump chamber contains a pair of rotary driven gears that mesh with each other along their outer circumference. The gears deliver fuel as a delivery medium from an intake chamber connected to a reservoir, along delivery channels formed between the circumference of the gears and the circumference walls of the pump chamber, to a pressure chamber. The gear pump also has a pressure limiting valve to limit the pressure in the pressure chamber. When a predetermined pressure in the pressure chamber is exceeded, the pressure limiting valve opens a connecting conduit between the pressure chamber and the intake chamber. The pressure limiting valve has a valve piston, which is guided so that it can move inside a bore in a plane perpendicular to the rotation axes of the gears and cooperates with a valve seat. The valve piston is able to move in opposition to the force of a prestressed spring. The pressure limiting valve makes it possible to limit the pressure generated by the gear pump and thus to limit the fuel quantity delivered. Usually, the fluid pump is preceded by a filter through which the aspirated fluid flows or is followed by a filter through which the delivered fuel

flows. The fluid pump delivers a varying fluid quantity depending on the degree to which the filter is soiled, a phenomenon that cannot be prevented by the pressure limiting valve.

[0004] Advantages of the Invention

[0005] The fluid pump according to the present invention, with the characterizing features of claim 1, has the advantage over the prior art that in addition to limiting the delivery pressure, it also regulates the delivery quantity so that the delivery quantity is fixed regardless of the degree to which the filter is soiled. This is achieved simply in that the force exerted on the valve piston in the closing direction is varied as a function of the pressure prevailing downstream of the filter.

[0006] Advantageous embodiments and modifications of the fluid pump according to the present invention are disclosed in the dependent claims. The embodiment according to claim 2 achieves the function of delivery quantity regulation in a simple manner. The embodiment according to claim 5 permits a simple design of the pressure limiting valve. The embodiment according to claim 6 provides a simple design of the connecting conduit. The embodiment according to claim 9 allows the delivery medium to be displaced from the chamber or to flow into it as the valve piston moves in the bore.

[0007] Drawings

[0008] An exemplary embodiment of the present invention is shown in the drawings and will be explained in detail in the subsequent description.

[0009] Fig. 1 shows a gear pump in a section along the line I – I in Fig. 2,

[0010] Fig. 2 shows the gear pump in a section along the line II – II in Fig. 1, and

[0011] Fig. 3 shows a schematic enlargement of the gear pump in a section along the line III – III in Fig. 2.

[0012] Description of the Exemplary Embodiment

[0013] A fluid pump depicted in Figs. 1 through 3 is embodied in the form of a gear pump and is positioned in a supply line, not shown, from a reservoir to a high-pressure fuel pump or fuel injection pump of a fuel injection apparatus of an internal combustion engine, for example belonging to a motor vehicle. The internal combustion engine is an autoignition engine and the fuel delivered by the gear pump is diesel fuel. The gear pump has a multipart housing that includes a housing part 10 and a cover part 12. Between the housing part 10 and the cover part 12, there is a pump chamber 14 that contains a pair of gears 16, 18 that mesh with each other along their outer circumferences. To form the pump chamber 14, the housing part 10 has two recesses 20, 22, each with a respective journal 24, 26 protruding from its

bottom. The journals 24, 26 are of one piece with the housing part 10 and extend at least approximately parallel to each other. In order to reduce the weight of the housing part 10, the journals 24, 26 can be embodied as at least partially hollow. The gear 16 has a bore 17 by means of which it is supported on the journal 24 in rotary fashion. The gear 18 has a bore 19 by means of which it is supported on the journal 26 in rotary fashion. The journals 24, 26 each define a rotation axis 25, 27 for the respective gears 16, 18. The cover part 12 is attached to the housing part 10, for example by means of a number of screws. The housing part 10 and the cover part 12 are preferably comprised of light metal, in particular aluminum. The gears 16, 18 are preferably comprised of steel, in particular sintered steel.

[0014] The gear pump has a drive shaft 30 that is supported so that it can rotate in the housing part 10. The drive shaft 30 is positioned at least approximately coaxial to the journal 24; the housing part 10 has a bore that continues inside the journal 24, through which the drive shaft 30 extends. A corrugated sealing ring is installed between the bore and the drive shaft 30 in order to seal the housing part 10. The drive shaft 30 is coupled to the gear 16, for example by means of a coupling member 36 situated between the end of the journal 24 and the cover part 12. During operation of the gear pump, the drive shaft 30 drives the gear 16 to rotate, which in turn transmits this rotary motion via face gearing to the gear 18, which is likewise provided with face gearing and meshes with the gear 16 on its outer circumference. The tooth engagement of the gears 16, 18 thus divides the pump chamber 14 into two subregions, a first subregion of which constitutes an intake chamber 40 and a second subregion of which constitutes a pressure chamber 42. The intake chamber 40 is connected to pressure chamber 42 by means of a delivery conduit 44 formed respectively between the tooth

grooves on the circumference surfaces of the gears 16, 18 and the upper and lower circumference wall of the pump chamber 14. The intake chamber 40 and pressure chamber 42 each have a connection opening in the wall of the housing part 10 or the cover 12 that connects the intake chamber 40 to an intake line, not shown, from the reservoir and connects the pressure chamber 42 via a delivery line, also not shown, to the intake chamber of the high-pressure fuel pump or the fuel injection pump. The connection opening in the intake chamber 40 constitutes an inlet opening 46 and the connection opening in the pressure chamber 42 constitutes an outlet opening 48.

[0015] The gear pump has a pressure limiting valve 50 that is situated in the housing, for example in the housing part 10. The bottom of the recesses 20, 22 constituting the pump chamber 14 have a groove 52 let into them, which extends between the pressure chamber 42 and the intake chamber 40. The groove 52 has a length l, a width b, and a depth t. Viewed in the direction of the rotation axes 25, 27 of the gears 24, 26, the groove 52 depicted in Fig. 3 extends approximately tangential to the gears 16, 18 and its length l is dimensioned so that the groove 52 protrudes beyond the intersecting lines 54 of the top circle Dk of the gears 16, 18. Viewed in the direction of the rotation axes 25, 27 of the gears 16, 18, the groove 52 is situated at least approximately in the center between the two gears 16, 18. The groove 52 thus constitutes a connecting conduit extending from the pressure chamber 42 to the intake chamber 40. Outside the groove 52, the bottom of the recesses 20, 22 of the housing part 10 is spaced slightly apart from the end faces of the gears 16, 18 in the axial direction.

[0016] A bore 56 whose diameter d is preferably a little larger than the width b of the groove 52 is let into the bottom of the groove 52. The bore 56 extends at least approximately parallel to the rotation axes 25, 27 of the gears 16, 18 and is preferably situated offset from a connecting line 58 between the rotation axes 25, 27 of the gears 16, 18 by a measurement H in the direction of the pressure chamber 42. The measurement H is preferably between approximately 2 and 5 mm. A valve piston 60 that functions as the valve member of the pressure limiting valve 50 is guided so that it can slide in the bore 56. A compression spring 62, for example in the form of the helical compression spring clamped between the valve piston 60 and the bottom of the bore 56, presses the valve piston 60 toward the end surfaces of the gears 16, 18 oriented toward it. The end surfaces of the gears 16, 18 are embodied as at least approximately flat and are positioned at least approximately perpendicular to their rotation axes 25, 27. The valve piston 60 rests against the end surfaces of the gears 16, 18 in the region in which their teeth engage with one another. The chamber 64 delimited in the bore 56 by the valve piston 60 at its rear end oriented away from the gears 16, 18 communicates with the intake chamber 40 via a bore 66 in the housing part 10.

[0017] The pressure prevailing in the pressure chamber 42 acts on part of the end surface of the valve piston 60 oriented toward the gears 16, 18, generating a force on the valve piston 60 in opposition to the force exerted on it by the compression spring 62. If the force of the compression spring 62 is greater than the force generated by the pressure prevailing in the pressure chamber 42, then the valve piston 60 rests against the end surfaces of the gears 16, 18, which constitute a valve seat. The valve piston 60, in cooperation with the gears 16, 18 thus disconnects the passage through the groove 52 and therefore the connection between the

pressure chamber 42 and the intake chamber 40. When the force of the compression spring 62 presses the valve piston 60 against the end surfaces of the gears 16, 18, this reduces the play of the gears 16, 18 in the pump chamber 14 in the direction of their rotation axes 25, 27, preferably eliminating it completely. This is advantageous particularly when starting the gear pump and when starting the internal combustion engine since the efficiency of the pump is then optimal. Through friction, the valve piston 60 exerts a braking force on the gears 16, 18, which is particularly advantageous when starting the gear pump since it achieves a greater flank contact between the teeth of the gears 16, 18. The favorable efficiency of the gear pump – particularly during its startup and during starting the internal question engine when it is necessary to deliver a large quantity of fuel – permits the dimensions of the gear pump to be designed for a smaller delivery quantity than known gear pumps.

[0018] When a predetermined pressure in the pressure chamber 42 is exceeded, then the force that the pressure exerts on the valve piston 60 exceeds the force of the compression spring 62 so that the valve piston 60 moves in opposition to the force of the compression spring 62 and lifts away from the end surfaces of the gears 16, 18. This opens the passage through the groove 52, thus establishing a connection between the pressure chamber 42 and the intake chamber 40 so that fuel can flow out of the pressure chamber 42 into the intake chamber 40, thus limiting the pressure in the pressure chamber 42. The pressure at which the pressure limiting valve 50 opens can be varied by means of the prestressing of the compression spring 62, the diameter of the valve piston 60, and the position of the valve piston 60 in relation to the pressure chamber 42 and therefore the size of the end surface of the valve piston 60 acted on by the pressure prevailing in the pressure chamber 42. With

increasing pressure in the pressure chamber 42, the valve piston 60 is slid further into the bore 56 so that the valve piston 60 opens an ever greater through flow cross section in the groove 52. The maximum through flow cross section that the valve piston 60 opens in the groove 52 is preferably great enough to allow the entire fuel quantity delivered by the gears 16, 18 to flow from the pressure chamber 42 back to the intake chamber 40 when the gear pump is not supposed to deliver any fuel. The cross-sectional area of the groove 52 that determines the maximum through flow cross section is preferably between 30 and 60 mm^2. When the valve piston 60 travels into the bore 56, it displaces fuel from the chamber 64 into the intake chamber 40 via the bore 66. When the valve piston 60 travels out from the bore 56, the chamber 64 can be refilled with fuel from the intake chamber 40 via the bore 66.

[0019] During operation of the gear pump, pressure pulsations occur due to the changing tooth engagement of the gears 16, 18 and the resulting volume of fuel displaced between the teeth. The valve piston 60 rests against the end surfaces of the gears 16, 18 in the region in which their teeth engage and is therefore acted on by the pressure prevailing between the teeth. When there are pressure pulsations between the teeth, the valve piston 60 moves out of the way, which damps and reduces these pressure pulsations.

[0020] The gear pump also has a bypass valve 70 that can open a connection between the pressure chamber 42 and the intake chamber 40 when the pressure in the pressure chamber 42 is less than that in the intake chamber 40. This can be the case particularly after the gear pump has run dry or when it is filled for the first time; the bypass valve 70 makes it possible to fill the gear pump and to bleed air from it. The bypass valve 70 has a valve member 72;

the pressure prevailing in the pressure chamber 42 acts on this valve member 72 and pushes it toward a valve seat 74 on the housing part 10. For example, the valve member 72 is contained in a recess 76 of the groove 52 in the region of the groove that protrudes into the pressure chamber 42. The valve member 72 can be comprised, for example, of an elastomer and the valve seat 74 can be embodied in the form of a flat seat. From the valve seat 74, a bore 78 leads into the chamber 64 in the bore 56 behind the valve piston 60 and this chamber 64 is in turn connected to the intake chamber 40 via the bore 66. The valve member 72 is also engaged by a closing spring 80, which can be embodied, for example, as a prestressed tension spring contained in the bore 78 and engages the valve member 72 at one end and hooks onto the last coil of the compression spring 62 at the other end. The closing spring 80 pulls the valve member 72 toward the valve seat 74 with a slight force, thus bringing it into contact with the valve seat 74 when the gear pump is not in operation. During operation of the gear pump, if the pressure in the pressure chamber 42 is lower than the pressure in the intake chamber 40, then the bypass valve 70 opens by virtue of its valve member 72 lifting away from the valve seat 74 so that fuel can travel from the intake chamber 40 directly into the pressure chamber 42 and the pressure chamber 42 is filled with fuel. If, during further operation of the gear pump, the pressure in the pressure chamber 42 increases and is greater than the pressure in the intake chamber 40, then this presses the valve member 72 against the valve seat 74 so that the bypass valve 70 closes, thus disconnecting the pressure chamber 42 from the intake chamber 40.

[0021] The gear pump is preceded in the fuel line by a filter 82 embodied in the form of a prefilter through which the fuel aspirated from the reservoir by the gear pump flows. The

gear pump is also followed in the fuel line by an additional filter 83 embodied in the form of a fine filter through which the fuel delivered by the gear pump flows to the high-pressure fuel pump for the fuel injection pump. It is also possible the pump to be provided only with the prefilter 82 upstream of the gear pump and not the fine filter. For example on the side of the housing part 10 oriented away from the cover part 12, the gear pump has an additional housing part 84 that has a recess oriented toward the housing part 10 in which a pressure chamber 85 is provided. The pressure chamber 85 is connected to a region downstream of the fine filter 83 so that the same pressure prevails in the pressure chamber 83 as downstream of the fine filter 83. When only the prefilter 82 is provided, then the pressure chamber 85 is connected to a region downstream of the prefilter 82 so that the same pressure prevails in the pressure chamber 85 as downstream of the prefilter 82 and upstream of the gear pump.

[0022] At its end oriented away from the housing part 10, the pressure chamber 85 in the recess of the housing part 84 is delimited by a moving wall 86 that is embodied, for example, in the form of a diaphragm. A sleeve 87 in the recess of the housing part 84 prestresses the diaphragm 86. The middle region of the diaphragm 86 supports a rod 88 that protrudes through a bore in the housing part 10 and rests against the valve piston 60. A prestressed spring 89 embodied, for example, in the form of a helical compression spring is contained in the part of the recess in the housing 84 that the diaphragm 86 separates from the pressure chamber 85. The pressure prevailing in the pressure chamber 85 thus acts on one side of the diaphragm 86 and the prestressed spring 89 acts on the other. When the pressure in the pressure chamber 85 is low, then the spring 89 pushes the diaphragm 86 and with it, the rod 88, toward the valve piston 60, which exerts an additional force on the valve piston 60 in the

closing direction in addition to that of the compression spring 62. When the pressure in the pressure chamber 85 is high, then the diaphragm 86 and with it, the rod 88, is pulled away from the valve piston 60 counter to the force of the spring 89 so that a lesser force acts on the valve piston 60 in the closing direction. If the fine filter 83 or the prefilter 82 is slightly soiled, then only a slight pressure loss occurs as the fuel flows through so that a relatively high pressure prevails downstream of the filter. In this case, the high pressure also prevails in the pressure chamber 85 so that the opening motion of the valve piston 60 is essentially determined by the compression spring 62. If the fine filter 83 or the prefilter 82 are heavily soiled, then a greater pressure loss occurs as the fuel flows through so that a relatively low pressure prevails downstream of the filter. In this case, a low pressure also prevails in the pressure chamber 85 so that in addition to the force of the compression spring 62, the force of the spring 89 also acts on the valve piston 60 in the closing direction and this valve piston 60 only opens in the presence of a higher pressure in the pressure chamber 42. The gear pump then generates a correspondingly higher pressure and delivers a greater quantity of fuel, thus compensating for the loss in pressure and quantity due to the filter 82 and/or 83.

[0023] Instead of being embodied as a gear pump, the fluid pump can also be alternatively embodied, for example, as an internal gear pump or as a vane pump in which the pressure limiting valve 50 can be used to regulate pressure and the pressure chamber 85 can be used to regulate delivery quantity in the same ways as described above.